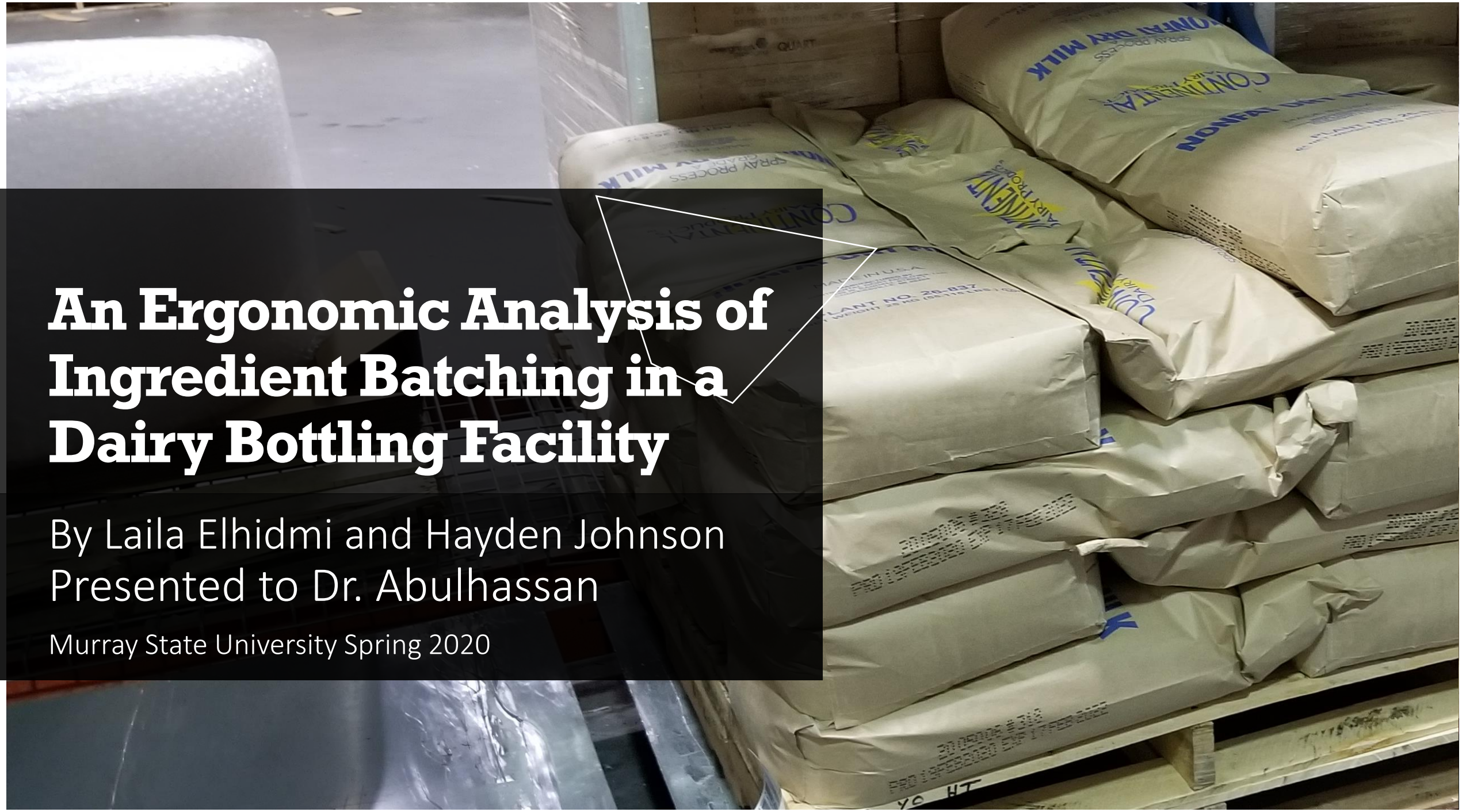
An Ergonomic Analysis of Ingredient Batching in a Dairy Bottling Facility

Hayden Johnson

Laila Elhidmi
Murray State University



An Ergonomic Analysis of Ingredient Batching in a Dairy Bottling Facility

By Laila Elhidmi and Hayden Johnson
Presented to Dr. Abulhassan

Murray State University Spring 2020

Contents

MURRAY STATE UNIVERSITY

Introduction

Dairy production facilities rely on batching operators to unload palletized ingredients and mix them into products that meet consumer specifications

Work-related musculoskeletal disorders (WMSDs) and injuries reported in the past five years:

- **One case of shoulder impingement syndrome**
- **One case of carpel tunnel syndrome (CTS)**
- **Two cases of trigger finger**
- **Three low back strains**
- **Six other cases of strains (wrist, elbow, shoulder)**

Frequent complaints of low-back pain, and concerns of ergonomic risk

Characterize the ergonomic risk factors associated with commonly performed batching processes and evaluate possible solutions

A Brief Review of Relevant Literature

According to an "Ergonomic Evaluations of Packaging Worker's Posture in a Manufacturing Company"

- **78% of employees abducted their upper arms**
- **18% were raising their shoulders**
- **7/10 indicated a high rating risk of upper body parts (neck, shoulder and wrist)**

Another study, "Association between postures and work-related musculoskeletal discomforts (WRMD) among beverage bottling workers" found,

- **Palletizing and depalletizing workers complained of pain or discomfort where the shoulders were raised and abducted >45 degree to reach overhead in order to remove or put back bags on the upper layers of the pallet or conveyor**
- **Depalletizing workers that reported discomfort = 52.2% neck, 73.5% shoulders, 38.1% wrist, and 61.1% lower back**
- **Palletizing workers that reported discomfort = 64.3% neck, 77.4% shoulders, 41.7% wrist, and 64.3% lower back**

Methods

Five subjects were observed performing daily job tasks in producing eight batches over a 12-hour shift

Age:

Mean = 46.78 years (SD = 14.18 years)

Sex :

80% males, 20% females

Weight:

Mean = 202.33 (SD = 25.94)

Height:

Mean = 70” (SD = 2.12”)

BMI:

Mean = 29.11 (SD = 4.27)

Equipment

Rapid Upper Limb Assessment (RULA), 3DSSPP Biomechanical Modeling, Lifting Fatigue Failure Tool (LiFFT), Bluebeam Revu 2019, tape measure, video recording equipment

MURRAY STATE UNIVERSITY

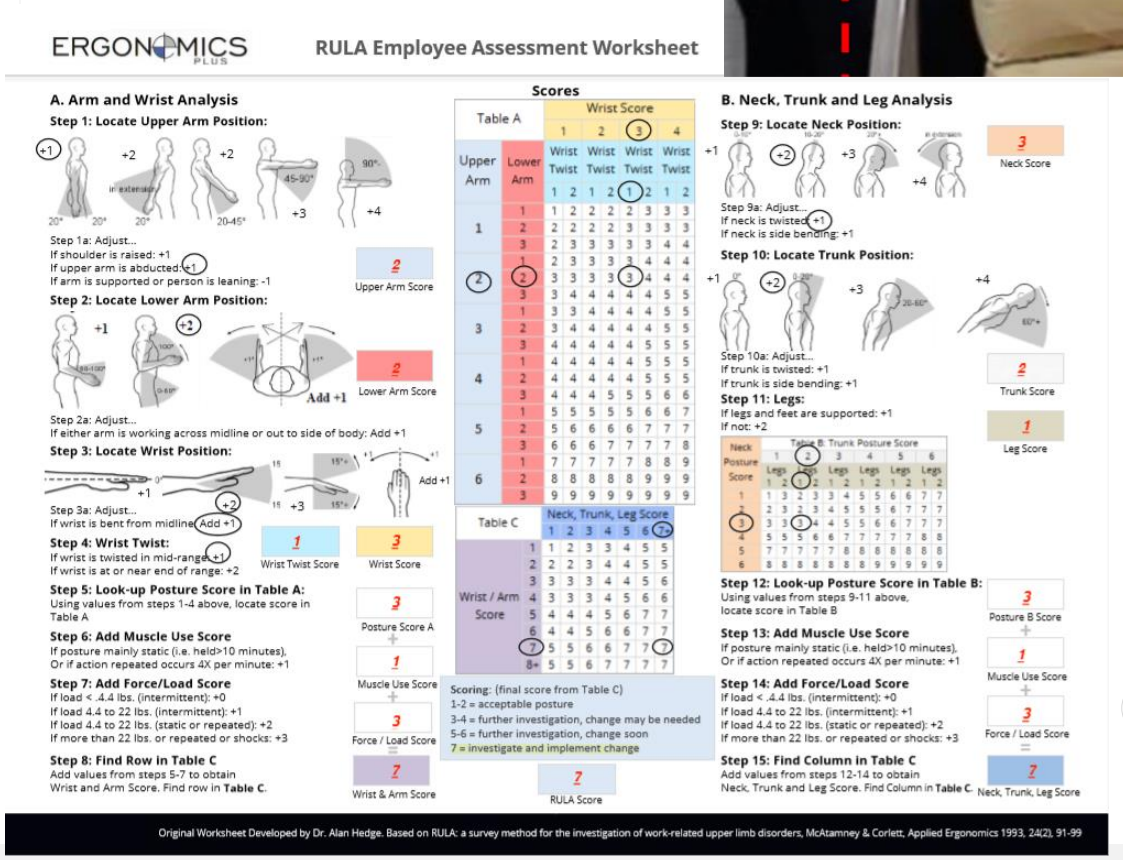
Analysis

Ergonomic analysis was performed remotely via collected photographs, video recordings, and measurements of the workspace

Rapid Upper Limb Assessment (RULA)

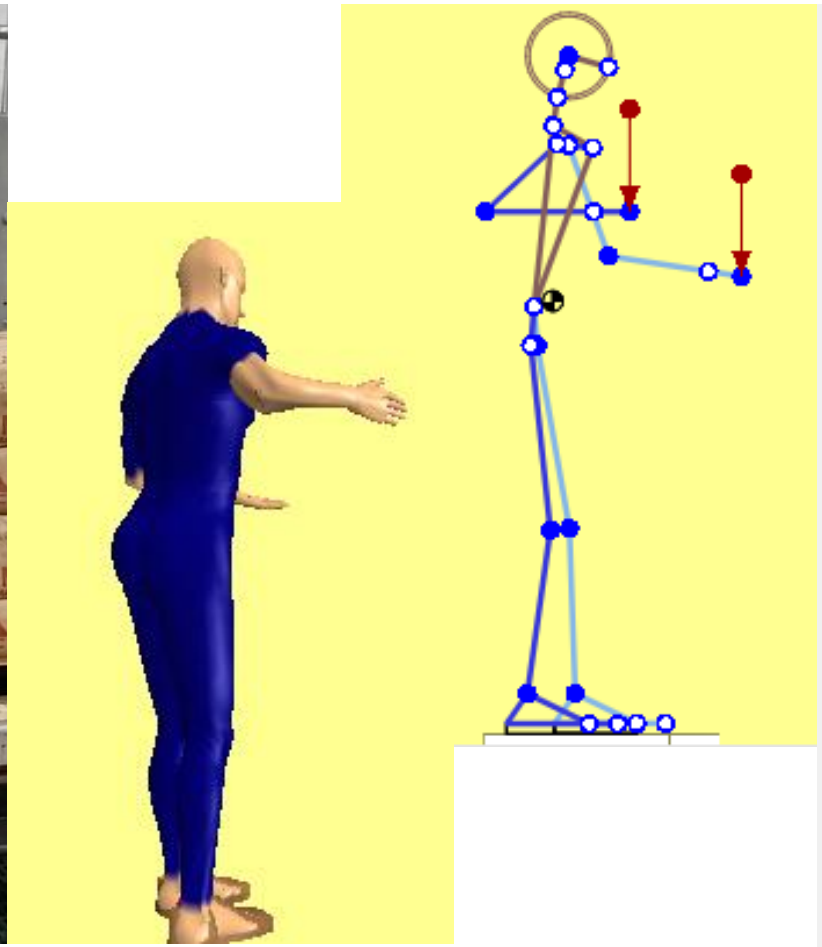
Multiple RULAs all resulted in score of 7 which indicates high ergonomic risk associated with routine postures

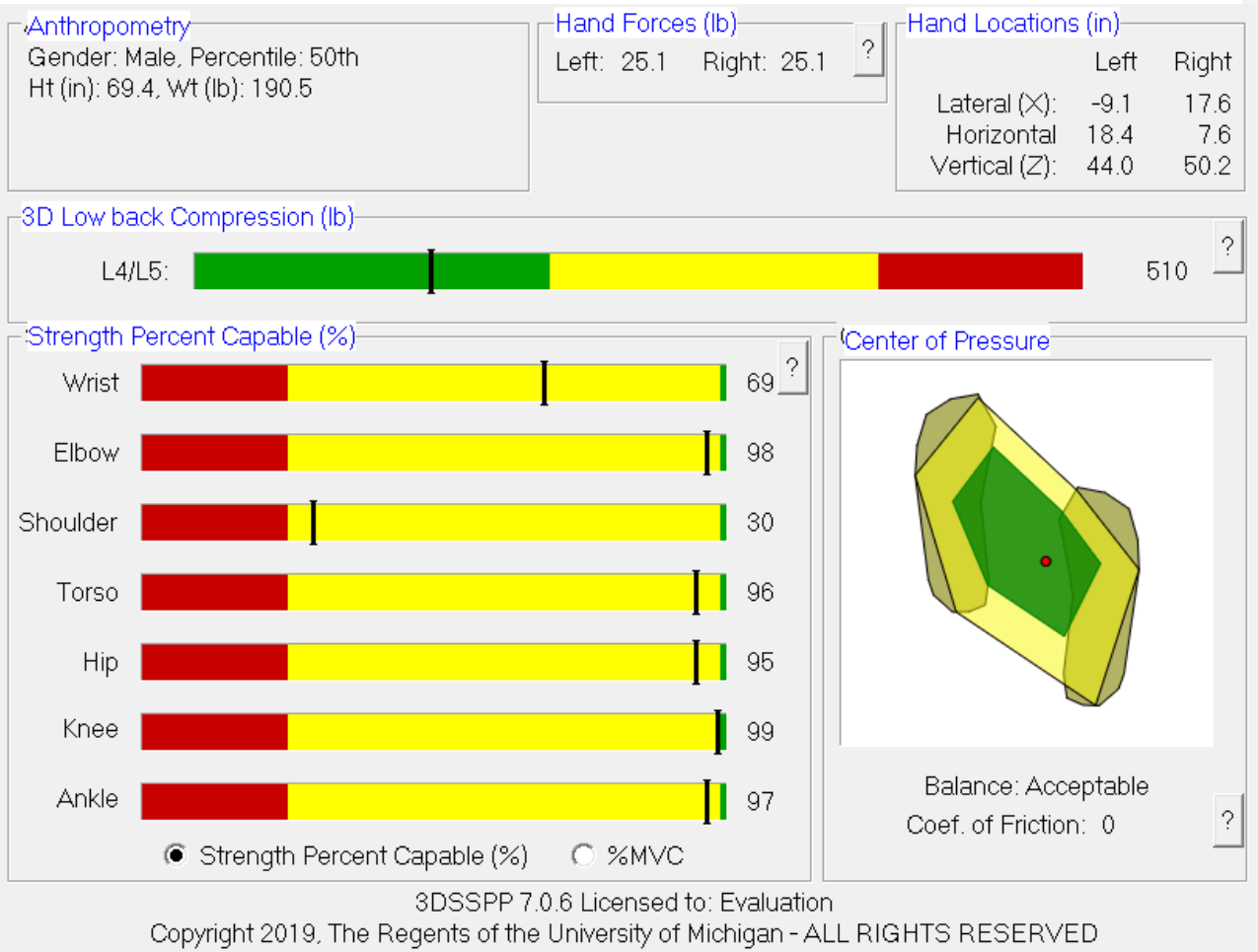
This task requires further investigation and the implementation of changes



3DSSPP Biomechanical Modeling

The model below estimates a compressive force of 510 lbs. in the L4/L5 disc and that 30% of 50th percentile males would have enough strength to exert the required load for five seconds with at least two minutes of rest





Lifting Fatigue Failure Tool (LiFFT)

According to this ergonomic evaluation tool, the combination of these tasks and estimated cumulative damage which may result is considered low-moderate, with a 30% probability of this job being high risk

The Lifting Fatigue Failure Tool

Unit: English | Metric

Task #	Lever Arm (inch)	Load (lb)	Moment (ft.lb)	Repetitions (per work day)	Damage (cumulative)	% Total (damage)
1	14.41	56.21	67.5	24	0.0011	35.5
2	11.893333	56.21	55.7	14	0.0004	12.9
3	13.695	50.4	57.5	9	0.0003	9.7
4	15.025	56.65	70.9	3	0.0002	6.5
5	13.57	50.4	57.0	4	0.0001	3.2
6	15.485	56.65	73.1	3	0.0002	6.5
7	28.35	43	101.6	2	0.0005	16.1
8	29.66	36	89.0	1	0.0001	3.2
9	12.53	8.6	9.0	12	0.0	0.0
10	28.76	36	86.3	2	0.0002	6.5
				Total Cumulative Damage:	**0.0031**	
				Probability of High Risk Job * (%):	**30.0**	

Reset Calculate

* A "High Risk Job" is defined as a job experiencing 12+ injuries per 200,000 hours worked, as defined by Marras et al. (1993).

Marras, W.S., Lavender, S.A., Leurgans, S.E., Rajulu, S.L., Allread, W.G., Fathallah, F.A., Ferguson, S.A. (1993). The role of dynamic three-dimensional trunk motion in occupationally-related low back disorders: The effects of workplace factors, trunk position, and trunk motion characteristics on risk of injury. Spine 18(5): 617-628.

Please cite this paper to support the authors:

Gallagher, S., Sesek, R. F., Schall, M. C., & Huangfu, R. (2017).
Development and validation of an easy-to-use risk assessment tool for cumulative low back loading: The Lifting Fatigue Failure Tool (LiFFT).
Applied Ergonomics, 63, 142-150.

Results

Current work practices in batching operations could significantly increase the risk of developing WMSDs

Materials handled:

Bagged ingredients weighing 45 – 56 lbs.

Repetitions:

Mean = 11.38 lifts/ingredient (SD = 14.00)

Frequency:

Mean = 5.134 lifts/min (SD = 4.41)

Current controls:

Pallet leveler, task rotations, stretching regiment

Tools	Result
RULA	7
3DSSPP (for 50th percentile male population)	L4/L5 Compressive Forces: Mean = 569.8 (SD = 92.608) Percentage of the population capable: Mean = 44.2 (SD = 26.95)
LiFFT	Probability of High-Risk Job: 26.06% (SD = 6.46)

Suggestions for Improvement

While batching operators are currently provided a pallet leveler, some pallets still exceed 72” in height at its lowest setting, above what is generally considered to be an acceptable starting height for lifts

If the current pallet leveler were lowered and a spring table lift/pallet carousel were mounted on top, this would provide additional adjustability along with the capability to rotate and bring the ingredients closer to the operator, eliminating the need for the operator to reach over the pallet to pull bags closer to them before lifting

Based on ingredient data collected, 50 lb. bags of compressed chocolate powder with a slick coating required 37.5% less force to pull compared to 50 lb. bags of loosely packed chocolate powder with a textured surface.

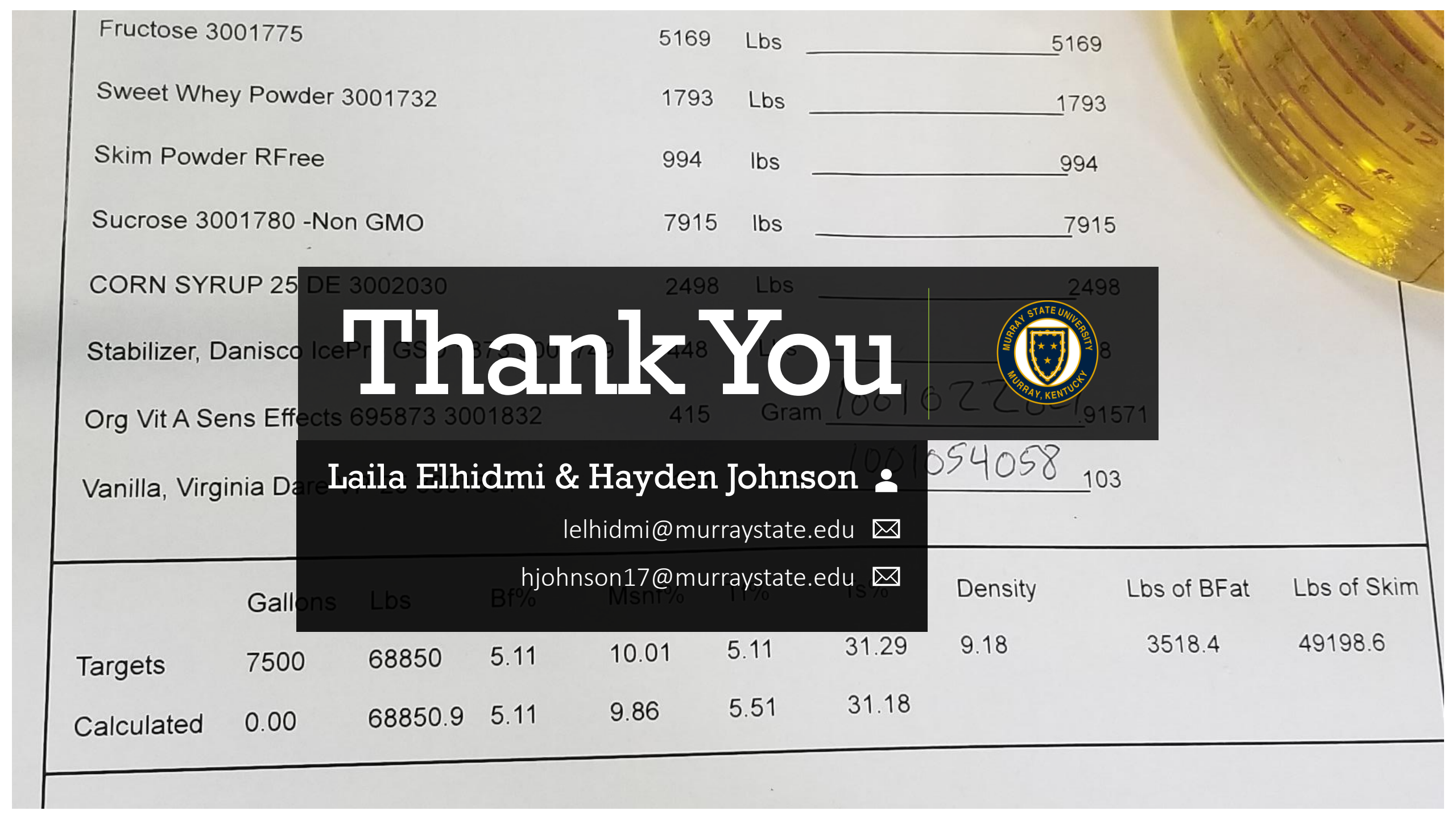
Conclusions

RULAs performed suggest that batching operators may be exposed to high levels of ergonomic risk, while the 3DSSPP and LiFFT assessments indicated low-moderate levels of risk

Previous injuries and MSDs have increased workers' discomfort and likely impacted job performance

Our suggestions will assist in eliminating the stress of repetitive lifting, bending, twisting, and reaching forward, in addition to maintaining the standard working height as the ingredients are unloaded from the pallets

Follow-up surveillance should be performed on-site after the implementation of the suggested improvements



Thank You

Laila Elhidmi & Hayden Johnson

lelhidmi@murraystate.edu

hjohnson17@murraystate.edu

References

Abaraogu, U., Odebiyi, D., & Olawale, O. (2016). Association between postures and work-related musculoskeletal discomforts (WRMD) among beverage bottling workers. *Work*, 54(1), 113–119. doi: 10.3233/wor-162262

Elfeituri, F., & Hammouda, A. (2012). Evaluating Physical Demand of Palletizing - Depalletizing Tasks: An Application in a Soft Drink Company. *Proceedings of the 2012 International Conference on Industrial Engineering and Operations Management*, 2343-2352.http://www.iieom.org/ieom2012/pdfs/555.pdf

Gallagher, S., & Heberger, J. R. (2015). The effects of operator position, pallet orientation, and palletizing condition on low back loads in manual bag palletizing operations. *International journal of industrial ergonomics*, 47, 84–92. https://doi.org/10.1016/j.ergon.2015.03.005

Garg, A., Waters, T., Kapellusch, J., & Karwowski, W. (2014). Psychophysical basis for maximum pushing and pulling forces: A review and recommendations. *International journal of industrial ergonomics*, 44(2), 281–291. https://doi.org/10.1016/j.ergon.2012.09.005

Ismaila, S. O., Salami, Y. A., Kuye, S. I., Dairo, O. U., & Adekunle, N. O. (2020). ERGONOMIC EVALUATION OF PACKAGING WORKERS' POSTURE IN A FOOD . *Engineering Studies and Research* , 26, 31–40. doi: 10.17758/eap.eap317022

Marras, W.S., Lavender, S.A., Leurgans, S.E., Rajulu, S.L., Allread, W.G., Fathallah, F.A., Ferguson, S.A. (1993). The role of dynamic three-dimensional trunk motion in occupationally-related low back disorders: The effects of workplace factors, trunk position, and trunk motion characteristics on risk of injury. *Spine* 18(5): 617-628.http://lifft.pythonanywhere.com/en/unit/english/

McAtamney, L. and Corlett, E.N. (1993) RULA: A survey method for the investigation of work-related upper limb disorders. *Applied Ergonomics*, 24 (2), 91-99. https://ergo-plus.com/wp-content/uploads/RULA.pdf

The Regents of the University of Michigan (2019) 3D Static Strength Prediction Program, 7.0.6. Retrieved from https://c4e.engin.umich.edu/tools-services/3dsspp-software/3dsspp-download/